National Renewable Energy Laboratory

Solar Radiation Research Laboratory (SRRL)

Instrument Calibrations

Weather Observations

Measurement Research Support

Measurements & Instrumentation Team

Distributed Energy Resources Center

http://www.nrel.gov/srrl

NREL • 1617 Cole Boulevard • Golden, Colorado 80401-3393 • (303) 275-3000
Operated for the U.S. Department of Energy by Midwest Research Institute • Battelle • Bechtel

Mission

Provide a unique outdoor research facility for supporting renewable energy conversion technologies and climate change studies for the U.S. Department of Energy (DoE).

Objectives

- Provide Improved Methods for *Radiometer Calibrations*
- Develop a *Solar Resource* Climate Database for Golden, Colorado
- Characterize *New Instruments* for Measuring Renewable Energy Resources
- Offer Unique *Training Methods* for Solar Monitoring Network Design, Operation, and Maintenance.

Approach

- Provide a site with excellent solar access on the South Table Mountain.
- Collocate a Metrology Laboratory for the calibration of all measurement and test equipment needed for NREL research.
- Conduct radiometer calibrations and characterizations traceable to international standards.
- Collect continuous research-quality measurements of solar radiation and other surface meteorological parameters.
- Provide NREL research programs with optimum instrument mounting platforms, automatic data acquisition systems, and research operation and maintenance procedures.
- Support the DoE Atmospheric Radiation Measurement (ARM) Program needs for radiometry applied to climate change research.

Current Activities

- Maintaining ***Metrology Lab*** procedures and calibration equipment traceable to national and international standards for electrical, pressure, and temperature measurements.
- Developing a new ***Optics Lab*** for making spectral irradiance measurements using standard lamps and spectroradiometers.
- Continuing operation of the ***Baseline Measurement System*** of more than 50 instruments to record surface meteorological conditions and make all data collected since 1985 available on the Internet.
- Performing annual comparisons of ***Absolute Cavity Radiometers Intercomparisons*** for transferring the World Radiometric Reference to international, national, and regional researchers.
- Conducting ***Broadband Outdoor Radiometer CALibrations (BORCALs)*** using specialized software for process automation and quality assurance.
- Performing ***Pyrgeometer Calibrations*** using the latest blackbody calibration system design.
- Supporting the long-term, ***outdoor performance testing*** of selected Photovoltaic (PV) Modules.
- Developing improved automated ***Quality Assessment*** software for processing solar radiation data from automated networks.

Contact Information

- NREL Home Page http:// www.nrel.gov
- Renewable Resource Data Center http:// rredc.nrel.gov
- Solar Radiation Research Lab http:// www.nrel.gov/srrl
- SRRL Manager e-mail: Tom_Stoffel @ nrel.gov
  or Phone: 303-384-6395

NREL / SRRL Tour Information

Who Are We?

Distributed Energy Resources Center (28 Staff)

- Distributed Power Systems Integration Team
- Hydrogen and Natural Gas Systems
- Resources and Environmental Evaluation Group ←Tour Focus
  - Resource Assessment Team
  - Measurements and Instrumentation Team

What Does Our Resources and Environmental Evaluation Team Do?

Provide renewable energy technologies with our knowledge of the integrated solar, wind, biomass, hydro, and geothermal energy resources and environmental aspects of system design, installation, and operation.

- We support industry, government, academia, and others by combining measurements and model estimates into data sets, maps, and Geographic Information System products necessary for renewable energy planning and development activities. ***http://rredc.nrel.gov***
- We assess our national strategic renewable energy reserves.
- We assist the DOE with climate change research and environmental evaluation of renewable energy options.

SRRL - Measuring Renewable Energy Resources

- Scientific and engineering research requires *measurements* & *models*
- We provide the "truth – in – measurements" through *calibration*
- Our labs at SRRL are designed to meet measurement research needs: Metrology / Optics / Data Acquisition / Electronics

Why is SRRL Here?

- Calibration of all measurement & test equipment for NREL and other DOE programs [the mesa's "free horizon" is perfect for radiometer calibrations]
- Local Weather database for device design and testing (e.g., PV devices)
- Research Support (e.g., an outdoor research lab for renewable energy instrumentation and collector developments)

What does SRRL Provide?

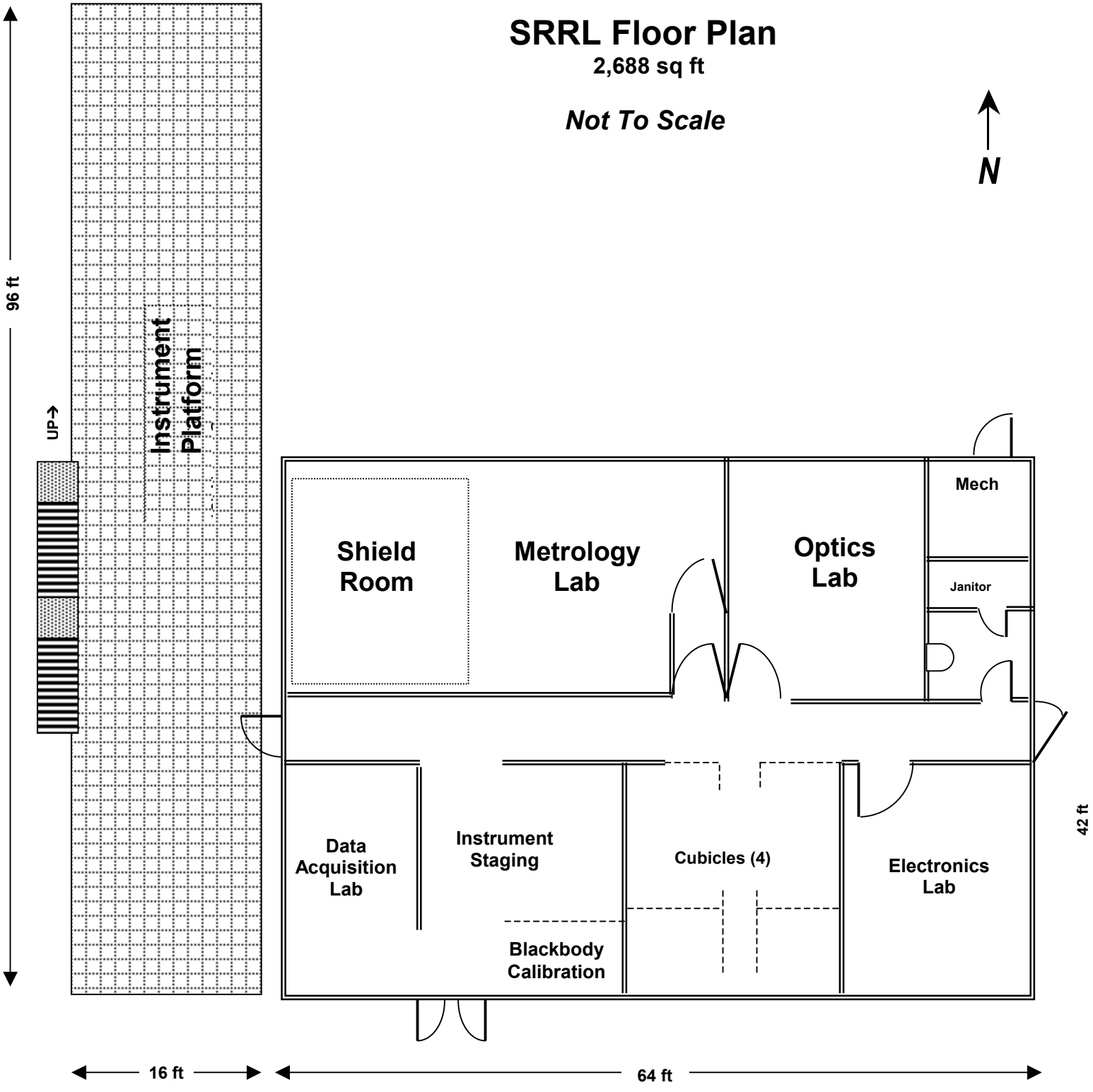
- We calibrate hundreds of instruments annually for all renewable energy technologies.
- Resource climatology for NREL
- We provide training for meteorological measurements and experiment design.

Visit us at ***http://www.nrel.gov/midc*** to see our other products and services.

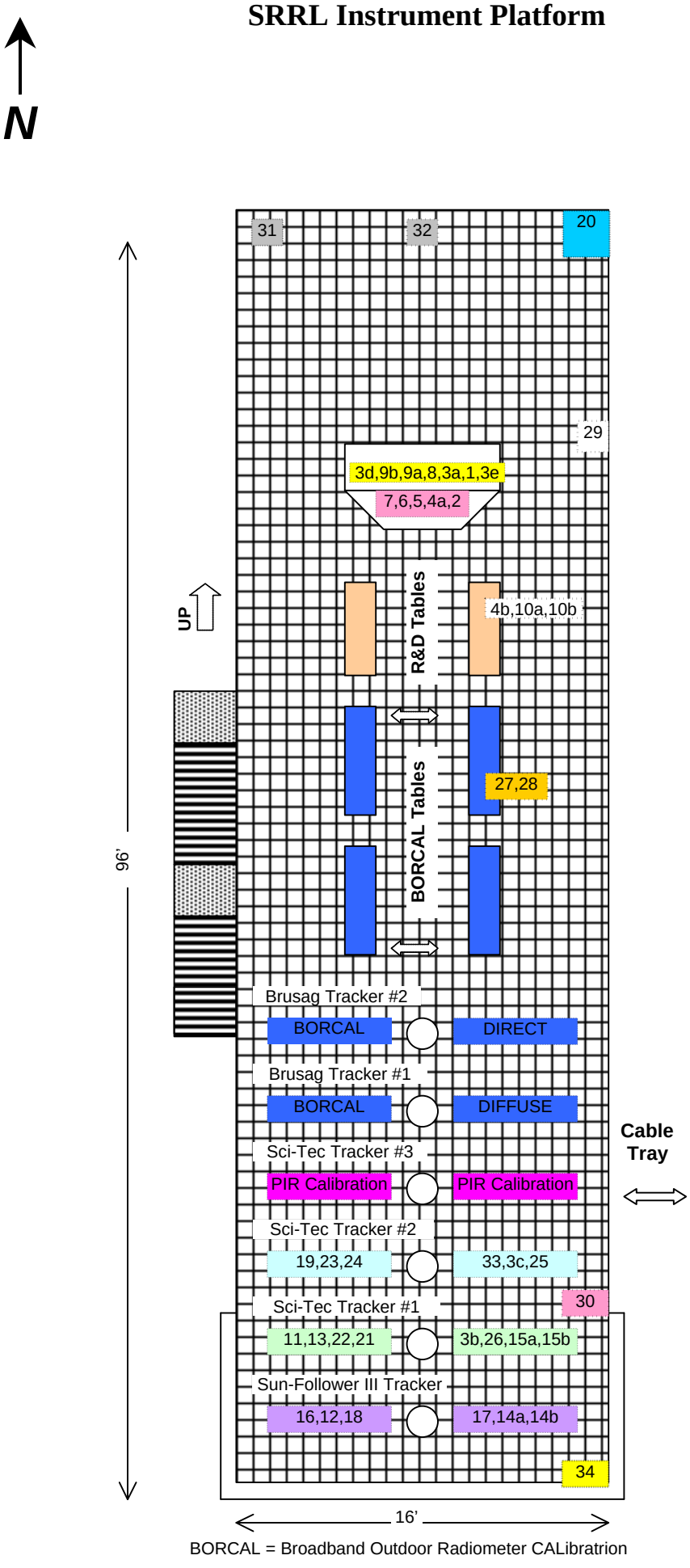
SRRL Floor Plan

2,688 sq ft

Not To Scale



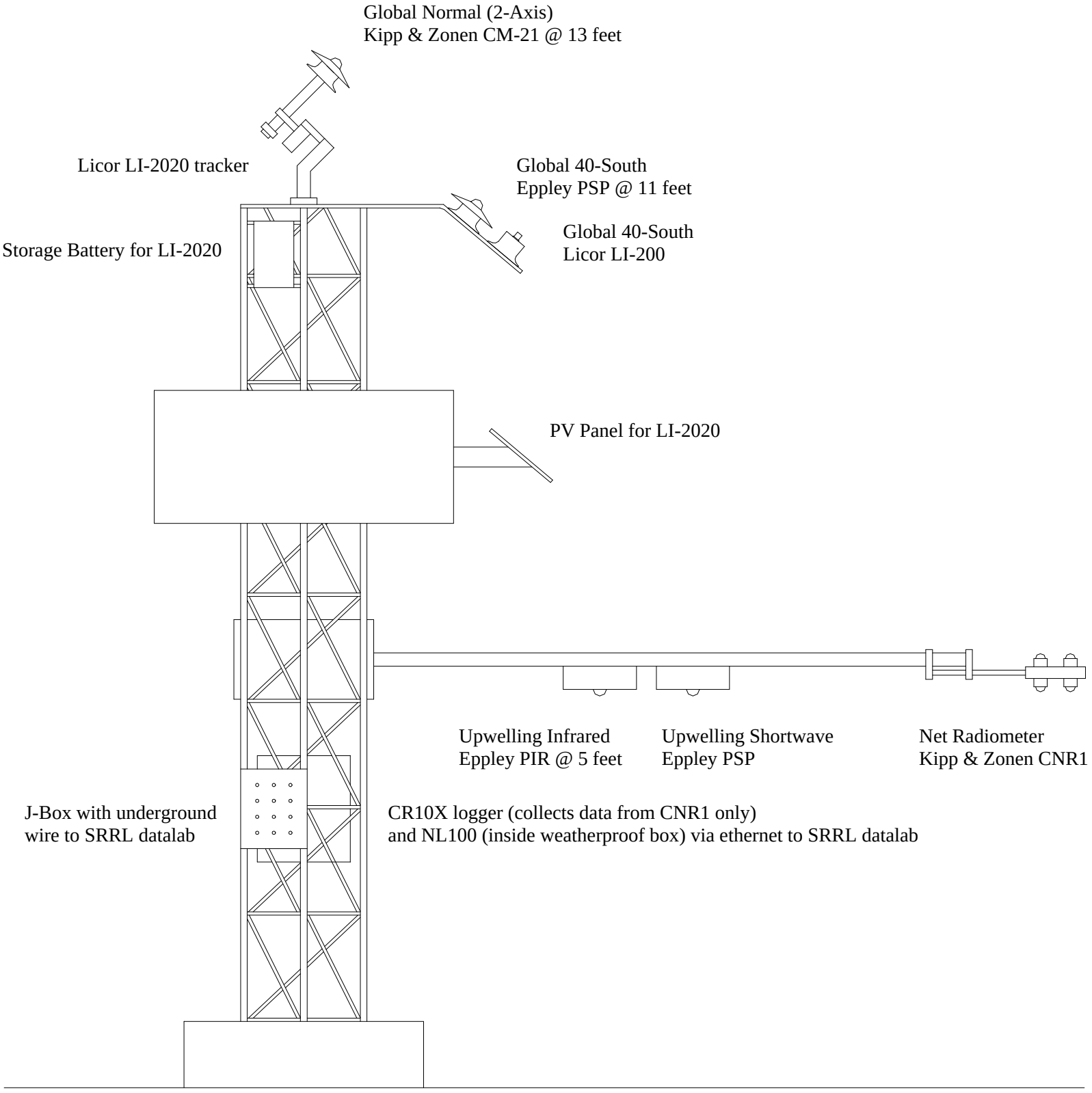
SRRL Instrument Platform



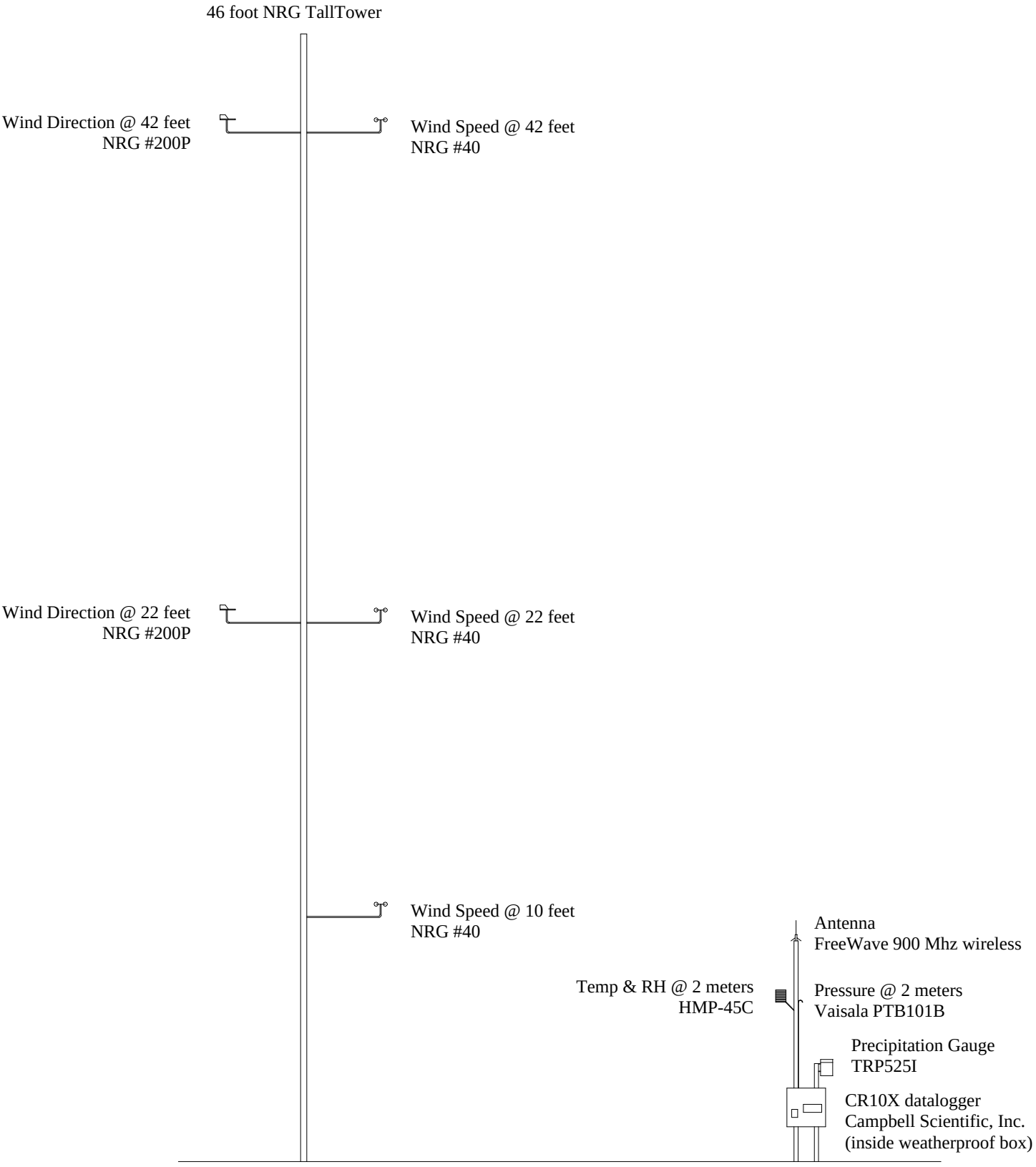
BORCAL = Broadband Outdoor Radiometer CALibratrion

1	Global – PSP Not Ventilated
2	Global – PSP Ventilated
3a	Global – Silicon (LI-200) Primary
3b	Global – Silicon (LI-200) Secondary
3c	Global – LI-190 Quantum (PAR)
3d	Global – Silicon Kipp SPLite
3e	Global – Kipp CM6b
4a	Global – PSP RG780 Ventilated
4b	Global – YES TSP-1
5	Total UV – Eppley TUVR
6	UVB – YES UVB-1 w/detector temp
7	UVB – Solar Light w/detector temp
8	UVB – EKO MS-210W
9a	UVA – Kipp CUVA1 w/detector temp
9b	UVB – Kipp CUVB1 w/detector temp
10a	UVA – Kipp UV-SAT w/detector temp
10b	UVB – Kipp UV-SBT w/detector temp
11	Spectral –Direct (LI-1800 w/fiber optic)
12	Direct – Primary NIP
13	Direct – Secondary NIP
14a	Direct – RG780 NIP
14b	Direct – Silicon LI-201
15a	Direct – UV EPLAB TUVR
15b	Direct – Kipp CH1
16	Direct – UVA Kipp CUVA2 w/detector T
17	Direct – UVB Kipp CUVB2 w/detector T
18	Direct – 500 nm (Ted's photometer)
19	Direct – 4 Chl EKO Photometer
20	Diffuse – PSP Shadowband (No Vent)
21	Diffuse – PSP Tracking Disk (Ventilated)
22	Diffuse – 8-48 Tracking Disk (Ventilated)
23	Diffuse – CM-22 Track Disk (Ventilated)
24	Diffuse – UVB – YES UVB-1 /w temp
25	IR Down – CG4 Track Disk (Ventilated)
26	IR Down – PIR Track Disk (Ventilated)
27	Deck Temperature (HMP-45C)
28	Deck Relative Humidity (HMP-45C)
29	Sky Scanner - EKO
30	Sky Camera - Afshin
31,32	Rotating Shadowband Pyranometers
33	AOCS (photometer head)
34	AOCS pyranometers & quantum sensors

SRRL Baseline Measurement System
Radiometer Tower

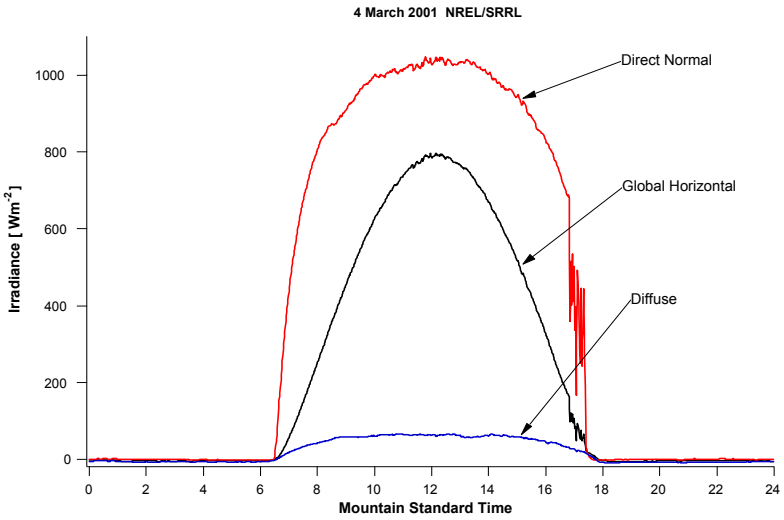


SRRL Baseline Measurement System
Meteorological Tower



Radiometer Calibrations Traceable to International Standards

Baseline Measurement System data are available on-line:



Solar Radiation Profiles for a mostly clear day in Spring

Unique Features of the Solar Radiation Research Laboratory

- Uniquely Qualified Staff
  A multi-discipline team of scientists, engineers, and technicians with experience in measurements and instrumentation for renewable energy research and development.

- Specially Designed
  Integrated functions to meet DOE/NREL needs for:
  -Metrology (calibration)
  -Optics
  -Electronics
  -Data Acquisition

- Location
  Unrestricted view of horizon from sunrise to sunset all year from South Table Mountain (1,829 m [6,000 ft] above sea level).

- Quantity of Instruments
  World's largest collection of radiometers in continuous operation.
  (45 instruments currently installed and maintained)

- Quality of solar irradiance measurements
  High resolution data (1- & 5-minute intervals) from World Meteorological Organization (WMO) first-class instruments.
  Daily instrument maintenance and annual calibrations.

- Longevity of Database
  Continuous measurements of basic solar radiation components since 1985.

- On-Line Access
  Data, images, and tutorial information are available from the Internet:
  http://www.nrel.gov/midc/

- Radiometer Calibrations
  Broadband and spectral references traceable to national and international standards.

Collaborative Research Examples

- **Colorado Department of Health**
  -Ozone Monitoring Station
- **Denver Urban Drainage & Flood Control District**
  -Precipitation Measurement Station
- **DOE Climate Change Research**
  -Atmospheric Radiation Measurement (ARM) Program
- **The Eppley Laboratory, Inc.**
  -Radiometer development characterization
  -Automatic Solar Tracker evaluation
- **European Solar Test Installation**
  -Absolute Cavity Radiometry
- **Korean Institute of Energy Research**
  -National Solar Measurement Network design & operations
- **King Abdulaziz City for Science & Technology**
  -Saudi Arabian Solar Measurement Network design & operations
- **Morocco Ministry of Mining and Energy**
  -Radiometer Calibration Facility
- **National Aeronautics & Space Administration**
  -Earth Observing Satellite Validation
- **National Center for Atmospheric Research**
  -Pyrgeometer Calibrations
- **National Oceanic & Atmospheric Administration**
  -Air Resources Laboratory
  -Climate Monitoring and Diagnostic Laboratory
  -National Climate Data Center
- **SCI-TEC Instruments, Ltd.**
  -Kipp & Zonen BV radiometer calibrations & characterizations
- **University of Colorado at Boulder**
  -Joint Center for Energy Management
- **World Meteorological Organization**
  -Baseline Surface Radiation Measurement Network
  -Absolute Cavity Radiometry